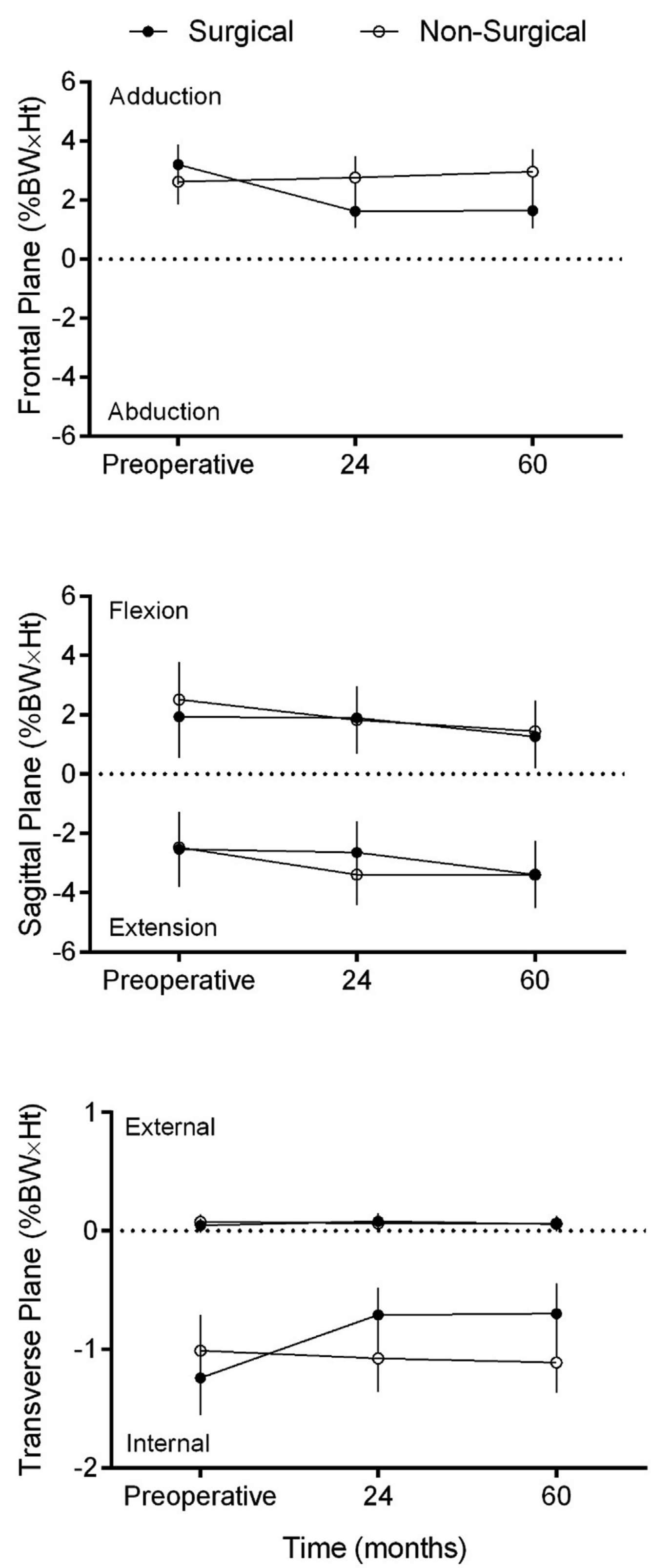

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IMPAIRMENTS AND ACTIVITY LIMITATIONS IN PEOPLE WITH FEMOROACETABULAR IMPINGEMENT: A SYSTEMATIC REVIEW

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Purpose: Femoroacetabular impingement (FAI) is a common condition that can cause hip and/or groin pain in young active adults, plus give rise to stiffness, muscle weakness, reduced physical function and lower quality of life. It has also been proposed as a risk factor for early onset of hip osteoarthritis. This impingement is due either to abnormalities in the morphology of the femoral head (cam impingement) or excessive acetabular coverage of the femoral head (pincer impingement) or in some cases, a combination of the two. Typically, impingement occurs with the combined movements of hip flexion, adduction and internal rotation. The development of rehabilitation strategies hinges on an in-depth understanding of the musculoskeletal impairments (e.g., hip joint biomechanics, kinetics, neuromuscular activity, strength, range of motion) and activity limitations associated with FAI. Knowledge of these impairments and activity limitations will also lend itself to assessing the effectiveness of surgical intervention as a means to restore normal musculoskeletal function. The purpose of this study was to systematically appraise the available literature with the aim of establishing (i) whether people with symptomatic FAI demonstrate performance-based impairments and/or activity limitations compared to people without; and (ii) the effect of treatment on these impairments and/or activity limitations.

Methods: Four electronic databases (Pubmed, CINAHL, SportDISCUS, and Cochrane Library) were searched until the third week of June 2013. Key search terms and synonyms were combined using database-specific truncation terms into three main filters. Eligibility was assessed by two independent reviewers with disagreements resolved by consensus or a third reviewer when required. After removal of duplicates from the initial yield, titles and abstracts were assessed and full texts were obtained for final eligibility screening. Studies were included if: the population had symptomatic FAI diagnosed by clinical and imaging features; the comparison was either healthy controls, the asymptomatic contralateral limb of participants with symptomatic FAI, or the study group post-intervention; and the reported outcomes included a measure of impairment and/or activity limitation. Methodological quality was assessed using the Newcastle-Ottawa Scale.

Results: Fifteen studies fulfilled the eligibility criteria. Ten used a cross-sectional design and five used an observational within-subjects study design with the FAI group evaluated pre- and post-intervention (3/5 also included a control group for comparison). Sample sizes varied between 10-37 participants. Seven of the 15 studies included participants with only cam type FAI, while the remainder included all FAI types. All studies utilized x-rays for radiographic diagnosis. The mean age of participants ranged from 24.7 years to 35.5 years across all cohorts. Only two studies had more female than male participants (64%, 60%). Outcome measures included range of motion (ROM) – measured via CT, 3-D motion analysis during gait, squatting, stair climbing; muscle strength, fatigue, neuromuscular activity. The only activity limitation evaluated was squatting ability. The most commonly reported impairment found was decreased range of motion (ROM) in positions of hip impingement. Other impairments included altered sagittal and frontal plane hip ROM during gait, altered sagittal plane hip ROM during stair climbing, decreased strength of hip adductors and flexors, and reduced activity of the tensor fasciae latae. Effects of surgery on impairments are conflicting but suggest improved hip ROM during gait, but not during stair climbing. Squatting depth in people with FAI is improved following surgical intervention.

Conclusions: People with symptomatic FAI demonstrate performance-based impairments and activity limitations. Surgical intervention may restore some deficiencies, but not all. Results reported are inconsistent and limited due to the paucity of studies in this area. Further studies of impairment and activity limitation prior to surgical intervention are needed to characterize the range of impairments in individuals with FAI. Understanding these potential deficiencies is necessary to inform appropriate rehabilitation programs, and to examine if these are a viable alternative to surgical intervention.

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EFFECT OF VARUS GAIT ON ANTERIOR CRUCIATE LIGAMENT: TO CLARIFY MECHANISM OF PATHOGENESIS OF KNEE OSTEOARTHRITIS

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A. Purpose: Knee osteoarthritis (OA) is one of the major health issues causing chronic disability. In clinical research, the instability of a knee joint results in both the joint structure changes and gait disorder. However the mechanism of pathogenesis of knee OA is unclear. Therefore we design a new hypothesis to explain mechanism of knee OA with quantitative analysis over the year. This study's objective is to estimate the effect of virtual varus gait patterns on knee ligaments by model of knee joint structure.

B. Methods: In this paper, effects of varus gait pattern on ligament are calculated using our developed musculoskeletal model. Firstly, knee joint model is developed considering characteristic anatomical structure, such as 6 degrees of freedom, 10 ligaments and 2 capsules. Next, our study uses inverse dynamics to calculate the effect of 10 different varus gait patterns on force generated in anterior cruciate ligament (ACL).

In order to calculate ligament force, we have developed three-dimensional musculoskeletal model which includes characteristic anatomical structure of knee joint.

The model is composed of 12 segments; HAT, pelvis, femur, patella, tibia-fibula, talus and foot. The model of right knee joint is developed based on anatomical characteristics; it contains 10 bundles of ligaments and 2 capsules. The same number of bundles is used as the previous work of Blankevoort *et al.* Force of bundles of ligaments is obtained by multiplication of stiffness and strain whereas stain is calculated by changes of bundles of ligament length from its natural length. The same parameters are used for stiffness and strain as work of Shelburne *et al.* SIMM (MusculoGraphics Corp.) works as a simulator of the model. This simulator can calculate inverse dynamics with using arranged model. Moreover, our knee joint model has 6 degrees of freedom in order to calculate accurate force of ACL: anterior-posterior, medial-lateral and superior-inferior, varus-valgus, abduction-adduction and flexion-extension. Translational movement (slides of femur) of knee joint is also considered besides its rotation. It is known that translational movement strongly depends on flexion angle of knee joint. Therefore sequential X-ray photograph provided by DeFrate *et al.* is used to decide the translational movement at different flexion angle of knee. Therefore this model can represent the accurate 6 degrees of freedom knee joint movement without measurement of precise knee joint position. In this study inverse dynamics is used to calculate the effect of gait patterns on ligaments using our developed model. Input data is gait pattern which has sequential three dimensional tracking data of markers on body and corresponded reaction force data by force plate. Output data is force of bundles of ligaments calculated by inverse dynamics calculation. Gait pattern is cropped from left leg toe off to right leg toe off which is half cycle of gait. Normal gait pattern is measured by optical motion capture system. Twenty-five markers are used based on Helen Hayes marker set, and reaction force is also measured at the same time. Varus gait patterns are used to calculate their effect on bundles of ligaments. Ten different varus gait patterns are generated based on different knee joint position. Knee joint position is shifted from the original position during normal gait pattern to lateral direction from 10 mm to 100 mm by 10 mm. The same reaction force data is used because other body segments except knee joint are unchanged.

C. Results: The force of posterior part of ACL in each gait patterns was calculated. Figure shows the change of force in half of gait cycle. The legend in the figure indicates the distance of lateral shift. Varus gait pattern caused larger force on ACL because ACL was extended by abduction between femur and tibia due to lateral shift. The peak of force occurred in about 60 % of half gait cycle. It can be implied that knee joint structure change occurs on this peak point. Non-linear relationship between gait patterns and maximum force of ACL was clarified from our knee joint model.

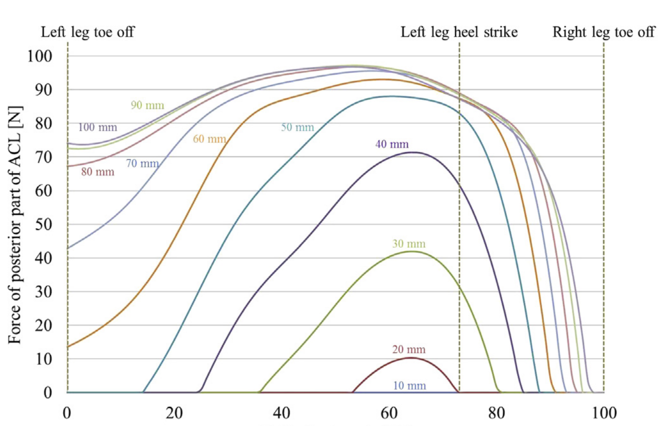

Figure: The force of posterior part of ACL.

D. Conclusions: The effect of varus gait pattern on a knee ligament is clarified. Our future direction is to develop mechanical model of ligament and cartilage to analyze the effect of secular changes of them.

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THE EFFECT ON GAIT BIOMECHANICS OF A NEW ORTHOSIS FOR HIP OA

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Purpose: Internal hip abduction moment is a major indicator for hip loading. A new hip bracing concept was developed to unload the cartilaginous area in hip osteoarthritis via an abduction and external rotation force intended to alter the weight bearing area and reduce compression through the joint. The present study was designed to test whether the brace reduces the internal hip abduction moment during gait of patients with hip osteoarthritis (OA) and investigates its effects on lower limb kinematics.

Methods: Gait analysis was performed on fourteen subjects with unilateral symptomatic hip OA. Pain, joint motion, moments and vertical ground reaction forces (zGRF) were compared between the braced and the unbraced (control), randomly assigned, conditions.

Results: Nine participants felt an immediate reduction of pain while walking with the hip brace (LP group: "Less Pain") and five other participants reported more pain or discomfort ("other" group). Over all participants peak hip abduction moment significantly decreased on the OA side ($p = 0.017$). Peak hip adduction ($i = 0.004$) and internal rotation ($p = 0.0007$) angles significantly decreased at stance with the brace. In the MP group there was a reduced zGRF at the first peak on the OA side to -377.7 $\pm$ 323.3%BW on average whereas the LP group did not show any reduced loading response.

Conclusions: Wearing the brace would appear to reduce the compressive joint reaction force at the femoroacetabular interface as indicated by a reduction in internal hip abduction moment along with immediate pain reduction in nine participants. In the LP group reduction in internal hip abduction moment may be achieved by a toe-out angle effect as the abduction and external rotation force of the elastic strap pulls the limb in stance outwards, whereas it probably resulted from a decreased demand on the OA limb in the "other group" as indicated by the decreased zGRF. Further long term studies on a bigger population are warranted to test whether acclimatization to the brace after longer use would show greater reduction in joint load and greater recruitment of the braced hip.

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KNEE JOINT LOADING INDICES BEFORE AND 3 MONTHS AFTER ARTHROSCOPIC PARTIAL MEDIAL MENISCECTOMY

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Purpose: Increased knee adduction moment (KAM) is considered an important marker of medial compartment loading in knee osteoarthritis (OA) research. Patients undergoing arthroscopic partial medial meniscectomy (APMM) are at increased risk of developing medial compartment knee OA. APMM may contribute to altered knee joint loading patterns. The aim of this pilot study was to determine the short-term changes in knee joint loading indices after medial APMM.

Methods: We investigated indices of knee joint loading using 3D gait analysis in 16 patients (13 men, 46.0 (SD 6.9 yrs), 178.7 (7.0) cm, 81.1 (10.7) kg, 25.4 (3.5) kg/m2) undergoing APMM for a medial meniscus tear. All patients had no radiographic knee OA (i.e. K/L grade 0 or 1) in the leg undergoing APMM and in their uninjured control leg at the baseline assessment prior to surgery. Exclusion criteria were: back problems, previous knee surgery, other co-morbidities affecting lower extremity function, low activity level (i.e. only indoor walking). Patients were assessed prior to and 3 months post APMM. Walking gait data were collected (100 Hz) using a 6-camera Vicon MX system (Vicon, Oxford, UK) with the Plug-in-Gait marker set. Ground reaction forces were recorded in synchrony with the cameras (1000 Hz) using two force plates (AMTI, OR6-7-1000, Watertown, MA, USA). The following indices of knee joint loading were calculated using inverse dynamics and reported relative to body size